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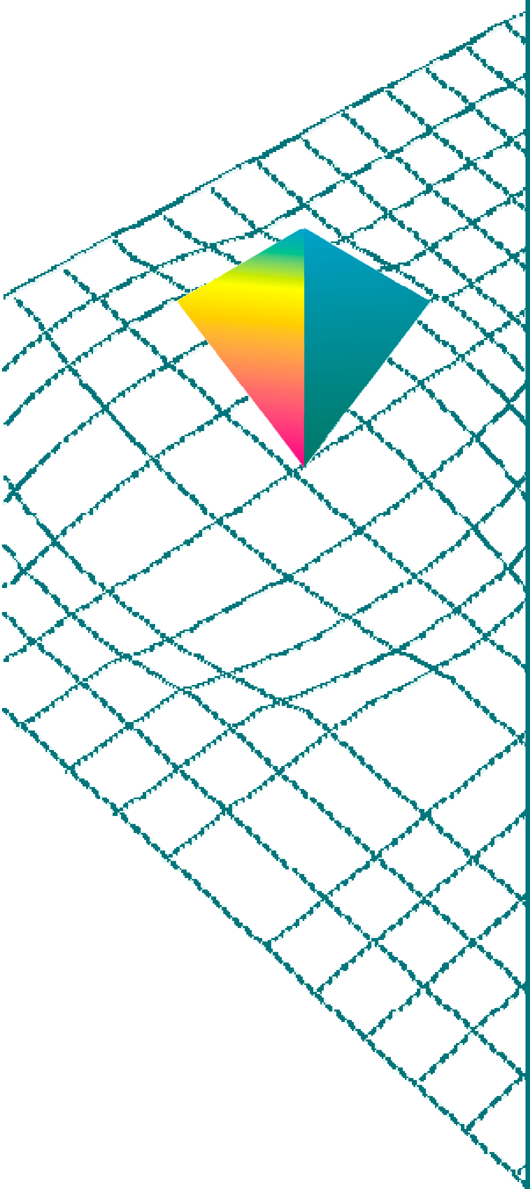

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50. Internationales Wissenschaftliches Kolloquium
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J. Bachvalov / V. Gretchikhin / E. Kallenbach

COMPUTER MODEL OF THE ELECTRIC FIELD IN THE CAPACITY SENSOR FOR THE ESTIMATION OF CONTROL DEPTH OF MATERIALS' PARAMETERS

ABSTRACT

COMPUTER MODEL OF THE ELECTROSTATIC FIELD IS OFFERED ON THE BASIS OF integral equations I and II sort. An instance of model operation of a superimposed capacity transmitter is considered on the basis of the built model.

CAPACITANCE PRINCIPLE OF MEASUREMENT AND CONTROL OF NON-ELECTRICAL quantities find wide application in a science and technique. On a design stage of a capacitive sensor it is necessary to have an association between sizes of a sensing device and control depth of the relevant parameter of a material (humidity, temperature, etc.), defining a quantity of a dielectric permeability and capacitance.

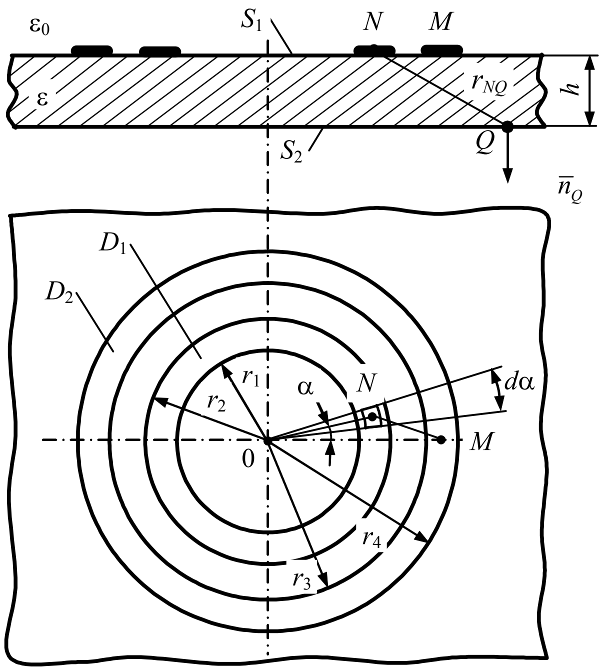

Fig. 1

In the given operation the problem about an estimation of depth control h_{dc} the superimposed sensor representing two concentric coplanar rings (fig. 1) is considered. We shall build a mathematical model for calculation of association of capacity of a sensor from thickness of a material h at known values of dielectric permeability ε of a material and radiuses of rings r_1, r_2, r_3, r_4. The model will allow to find magnitude h_{dc} such, that at $h > h_{dc}$ the capacity of a sensor remain practically equal capacity at h_{dc}.

Thickness of rings we shall count infinitesimal. We use the known relations linking charges of conductors q_1 and q_2 and their potentials U_1 and U_2:

$$q_1 = C_{11}U_1 + C_{12}\left(U_1 - U_2\right); \quad q_2 = C_{22}U_2 + C_{12}\left(U_2 - U_1\right). \tag{1}$$

For an electro-neutral system we have $q_2 = -q_1$; from (1) follows $U_2 = -\left(C_{11}/C_{22}\right)U_1$, the capacity sensor can be calculated by formula

$$C = \left|\frac{q_1}{U_1 - U_2}\right| = \frac{C_{11}C_{22} + C_{11}C_{12} + C_{22}C_{12}}{C_{11} + C_{22}}.$$

For definition of magnitudes C_{11}, C_{22}, C_{12} it is necessary to execute calculations of charges, considering known potentials U_1 and U_2, under following conditions:

1) $U_1 = U_2$, then $q_1 = C_{11}U_1 \Rightarrow C_{11} = \left|q_1/U_1\right|$; $q_2 = C_{22}U_2 \Rightarrow C_{22} = \left|q_2/U_2\right|$;

2) $U_1 = 0; U_2 \neq 0$, then $q_1 = -C_{12}U_2 \Rightarrow C_{12} = \left|-q_1/U_2\right|$.

For definition q_1 and q_2 it is necessary to calculate an electric field of a sensor. We shall reduce calculation of a field in a sectionally homogeneous medium to calculation of a field in a homogeneous medium. For this purpose on demarcations of mediums S_1 and S_2 we shall inject fictitious charges with a density $\sigma(Q)$ for which definition we use boundary conditions

$$U^+ = U^-; \varepsilon\frac{\partial U^+}{\partial n} = \varepsilon_0\frac{\partial U^-}{\partial n},$$

where the sign + means area of a dielectric, a sign – area with ε_0.

In outcome we shall receive a system of integral equations concerning unknowns values of surface densities of charges $\sigma(N)$ and $\sigma(Q)$:

$$\begin{cases} \displaystyle\iint_D \frac{\sigma(N)\,dS_N}{r_{NM}} = 4\pi\varepsilon_0 U(M); \\ \displaystyle\sigma(Q) - \lambda\iint_F \frac{\sigma(N)\cos\left(\overline{r}_{NQ}, \overline{n}_Q\right)}{2\pi r_{NQ}^2}dS_N = 0, \end{cases} \tag{2}$$

where $D = D_1 \cup D_2 \cup S_1 \cup S_2$; $M \in D_1 \cup D_2$; $\lambda = (\varepsilon - \varepsilon_0)/(\varepsilon + \varepsilon_0)$; $F = D_1 \cup D_2 \cup S$; $S = S_1$; if, $Q \in S_2$; $S = S_2$, if $Q \in S_1$; $r_{NQ} = \sqrt{r_N^2 + r_Q^2 + h^2 - 2r_N r_Q\cos\alpha}$.

System (2) we shall reduce to a system of the linear algebraic equations which solution will allow to find sequentially $\sigma(N) \to q_1$ and $q_2 \to C$. With the help of the built model association between h_{dc} and r_4 is obtained.

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